FHP: A New Helicopter Autopilot

FHP Series is a line of new, innovative autopilots, designed for, but not exclusively, miniature remote control helicopters to enable their transformation into an Unmanned Aerial System. FHP Series differentiates itself from the competition with an explicit focus on safety, reliability, performance and flexibility.

FHP Series 1, currently under development, is the first member of this series. Series 1 is a small, powerful single processor autopilot powered by safety-focused software. Long term, a Series 2 is envisioned to introduce further hardware redundancy to ensure performance even in the face of hardware faults.

Kwan: A Real-Time Kernel

FHP Series 1 is being used as a proving platform for a new novel kernel, a key software component of an embedded system, called Kwan. Kwan aims to simplify and quicken software development, while at the same time improving software safety, reliability and correctness through the features below.

Kwan Key Features

- **High assurance by design**: Due to its key role in an embedded system, it is essential Kwan’s code is correct. That is why Kwan is developed using Spark, a language designed for safety- and security-critical software development. With its toolkit, Spark allows formal verification of Kwan to ensure correctness, resulting in higher safety and reliability.
- **Defining tasks the sensible way**: In commercial real-time kernels, task properties, like how often a task runs, are buried in code. This causes difficulties with management and analysis of these properties. Kwan makes use of the fact that in safety-critical systems, like FHP Series, all tasks are known at runtime and thus task properties can be defined in one place.
- **Intelligent Scheduling**: In an embedded system, the running time of a task is frequently determined by the sensor data received. By making the Kwan’s scheduler aware of sensor data, it is believed that more intelligent and efficient scheduling decisions can be made, improving safety and reliability by ensuring free resources are available if trouble arises.
- **Guaranteeing Quality**: Kwan introduces the concept of Quality of Service (QoS) for sensors by collecting information on abnormal or missing sensor data. This data allows the scheduler to postpone or run alternative tasks to ensure system safety and performance during short-term data loss or to reduce performance to a safe state if the abnormality is permanent.

FHP Series 1 Key Features

**Processor**
Freecale’s automotive microcontrollers are designed to run the increasingly complex real-time control algorithms required by today’s modern car engines, in the extremely harsh environment of the automotive powertrain. The result is a unique processor that provides both the performance and reliability demanded by FHP Series 1.

**Communication**
To ensure safe and reliable communication, FHP Series 1’s low powered communications module operates on two distinct frequencies, allowing the helicopter to communicate even if one of the channels is affected by severe noise. Dual antennas for each frequency are used to improve communication in the presence of obstacles.

**Size**
FHP Series 1 was designed to be small enough that it would fit on a 500 class model helicopter (about the same size as the lower half of this poster), while providing the resources to control the helicopter to communicate even if one of the connectors are available to interface FHPS1 to new sensors and actuators. The individual boards making up FHP S1 can also be replaced, allowing, for example the communications to be upgraded.

**Expansion**
Modifications to FHP Series 1 can be easily carried out to suit end user’s requirements thanks to its open and modular design. Input and output connectors are available to interface FHP S1 to new sensors and actuators. The individual boards making up FHP S1 can also be replaced, allowing, for example the communications to be upgraded.

**Power Redundancy**
Two power sources can be used to ensure that it would fit on a 500 class model helicopter (about the same size as the lower half of this poster), while providing the resources to control the helicopter to communicate even if one of the connectors are available to interface FHP S1 to new sensors and actuators. The individual boards making up FHP S1 can also be replaced, allowing, for example the communications to be upgraded.

**Navigation**
FHP Series 1 uses GPS, Inertial Measurement Unit (IMU), barometric altimeter and aspirated sensor data to provide high resolution, timely position and motion data. Its modular design enables the GPS and IMU to be chosen based on operational requirements. Other sensors, like a radar altimeter, can also be added for improved performance.

**Power Efficiency**
Power is a scarce commodity on a small model helicopter, and so FHP Series 1 is designed to make do with less. This has been achieved by using application specific microcontrollers, and low power sensors and radio communication. In particular, the battery to system voltage converter is designed to be small enough to fit on a 500 class model helicopter (about the same size as the lower half of this poster), while providing the resources to control the helicopter to communicate even if one of the connectors are available to interface FHP S1 to new sensors and actuators. The individual boards making up FHP S1 can also be replaced, allowing, for example the communications to be upgraded.

**Task Management**
In commercial real-time kernels, task properties, like how often a task runs, are buried in code. This causes difficulties with management and analysis of these properties. Kwan makes use of the fact that in safety-critical systems, like FHP Series, all tasks are known at runtime and thus task properties can be defined in one place.

**QoS for Sensors**
Kwan introduces the concept of Quality of Service (QoS) for sensors by collecting information on abnormal or missing sensor data. This data allows the scheduler to postpone or run alternative tasks to ensure system safety and performance during short-term data loss or to reduce performance to a safe state if the abnormality is permanent.